Characterizing Thermal and Hydrological Properties of Hydrate-Bearing Sediments

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RESEARCH OBJECTIVES

Predicting natural gas recovery from reservoirs containing gas hydrates requires knowledge of both the reservoir properties and the properties and processes of hydrate dissociation. The main objective of this study is to perform laboratory tests to determine the thermal and physical properties of hydrate-bearing porous media, including thermal conductivity, kinetic parameters, and relative permeability.

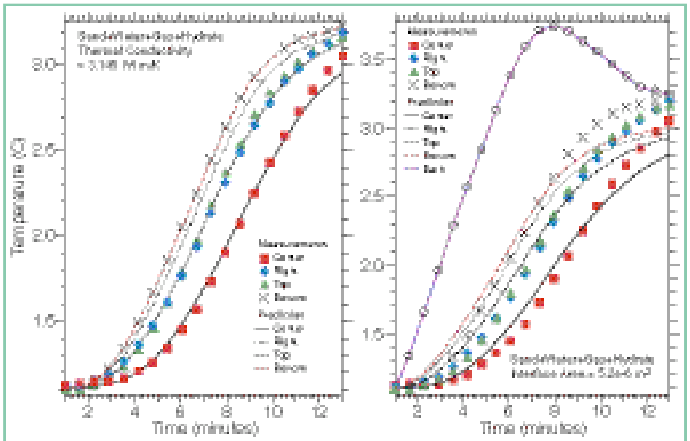

Figure 1. Calibration and parameter determination of the hydrate-bearing sand/water/gas/hydrate system (symbols represent measurements, lines represent model predictions)

APPROACH

To estimate thermal conductivity and kinetic parameters, we formed and dissociated methane hydrate in partially water-saturated sand contained in an x-ray-transparent aluminum pressure vessel. The sediment/hydrate sample was subjected to either thermal perturbations within the hydrate stability zone, or thermal or pressure perturbations leading to dissociation. History matching and inverse modeling with iTOUGH2 and TOUGH-Fx/Hydrate were performed to estimate the properties.

New laboratory tests were performed to estimate the relative permeability of hydrate-bearing porous media using a transient technique. Inverse modeling using iTOUGH2 was performed to optimize relative permeability curves, so as to provide saturation profiles that best match the x-ray computed tomography data.

ACCOMPLISHMENTS

Inverse modeling analysis of the experiments has provided needed estimates of the thermal properties and kinetic parameters of hydrate dissociation in porous media. We numerically inverted the thermal response of the system with and without hydrate, and determined the thermal conductivities of the sand/water/gas system and the sand/water/gas/hydrate system. The thermal conductivity of the system with hydrate exceeded that of the same sample prior to hydrate formation, in spite of the similar thermal conductivities of water and hydrate.

Using the thermal conductivities, we determined intrinsic rate constants and the activation energy of methane-hydrate-dissociation reactions by means of inverse modeling. The good agreement between numerical predictions and observations of pressure, temperature, and methane releases validated the parameters determined through the inversion process. Comparison of the results from the hydrate-bearing porous media to pure methane-hydrate samples has provided an initial measure of the effect of porous media on the kinetics of hydrate dissociation. The relative permeability measurements are in progress.

SIGNIFICANCE OF FINDINGS

Because of the strongly endothermic nature of hydrate dissociation and the importance of heat transfer, knowledge of the reaction kinetics and thermal properties of hydrate-bearing geological media is of critical importance to reliably predicting the gas production potential of natural gas hydrate deposits. These measurements and complementary modeling techniques should provide useful clues for understanding how natural gas can be produced from hydrate-bearing reservoirs.

RELATED PUBLICATIONS

Kneafsey, T.J., L. Tomutsa, G.J. Moridis, Y. Seol, B. Freifeld, C.E. Taylor, A. Gupta, Methane hydrate formation and dissociation in a partially saturated sand—Measurement and observations. In: 5th International Conference on Gas Hydrates, Trondheim, Norway, 2005. Berkeley Lab Report LBNL-57300.

Moridis, G.J., Y. Seol, T.J. Kneafsey, Studies of reaction kinetics of methane hydrate dissociation in porous media. In: 5th International Conference on Gas Hydrates, Trondheim, Norway, 2005. Berkeley Lab Report LBNL-57298.

ACKNOWLEDGMENTS

This work was supported by the Assistant Secretary for Fossil Energy, Office of Natural Gas and Petroleum Technology, through the National Energy Technology Laboratory, under the U.S. DOE Contract No. DE-AC03-76SF00098.